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ARTICLES

Relation of Left Ventricular Mass and Geometry to Morbidity and Mortality in Uncomplicated Essential Hypertension

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Objective: To assess the prognostic significance of left ventricular mass and geometry in initially healthy persons with essential hypertension.

Design: An observational study of a prospectively identified cohort.

Setting: University medical center.

Patients: Two hundred and eighty patients with essential hypertension and no pre-existing cardiac disease were evaluated using echocardiography between 1976 and 1981. Two hundred and fifty-three subjects or their family members (90%) were contacted for a follow-up interview an average of 10.2 years after the initial echocardiogram was obtained; the survival status of 27 patients lost to follow-up was ascertained using National Death Index data.

Measurements and Main Results: Left ventricular mass exceeded 125 g/m² in 69 of 253 patients (27%). Cardiovascular events occurred in a higher proportion of patients with than without left ventricular hypertrophy (26% compared with 12%; $P = 0.006$). Patients with increased ventricular mass were also at higher risk for cardiovascular death (14% compared with 0.5%; $P < 0.001$) and all-cause mortality (16% compared with 2%; $P = 0.001$). Electrocardiographic left ventricular hypertrophy did not predict risk. Patients with normal left ventricular geometry had the fewest adverse outcomes (no cardiac deaths; morbid events in 11%), and those with concentric hypertrophy had the most (death in 21%; morbid events in 31%). In a multivariate analysis, only age and left ventricular mass—but not gender, blood pressure, or serum cholesterol level—independently predicted all three outcome measures.

Conclusions: Echocardiographically determined left ventricular mass and geometry stratify risk in patients with essential hypertension independently of and more strongly than blood pressure or other potentially reversible risk factors and may help to stratify the need for intensive treatment.

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Approximately 25% of adults in the United States are hypertensive (1). Although hypertension is a potent cardiovascular risk factor, antihypertensive treatment has reduced morbidity and mortality from cardiovascular disease less than would be expected for the degree of blood pressure reduction (2-6). These results have led investigators to seek better means of stratifying risk among hypertensive patients, to direct more effective treatment to those at the highest risk, and to minimize the costs and side effects of treatment for those at the lowest risk.

The risk for complications in patients with any level of blood pressure has long been known to be greater in those with left ventricular enlargement detected by electrocardiography or chest radiography (7-11). Unfortunately, these techniques are insensitive and identify left ventricular hypertrophy in few patients with hypertension of average severity (12-16).

In recent years, echocardiography, a noninvasive method of measuring left ventricular size and mass accurately and at moderate cost (17), has become widely available. Previous studies have shown that echocardiographically detected left ventricular hypertrophy predicted cardiovascular complications during 4- to 5-year follow-up periods in hypertensive men (18) and in healthy members of the general population (19, 20). However, whether ventricular mass measurements identify longer-term high-risk status in hypertensive women as well as men, whether risk stratification can be further improved by more complete assessment of left ventricular geometry, and whether consideration of left ventricular mass in multivariate analyses affects the independent prognostic value of conventional risk factors are all unknown. In our study, a prospectively identified cohort of initially healthy hypertensive men and women was followed for 10 years. Death and nonfatal morbid events were used as endpoints.

Methods

Patients

Study patients were selected prospectively from 412 consecutively seen hypertensive men and women referred for echo-

Table 1. Characteristics of Study Patients*

Characteristic	All Patients (n = 253)	Patients with Left Ventricular Mass Index		P Value
		< 125 g/m ² (n = 184)	≥ 125 g/m ² (n = 69)	
Age, y	47.1 ± 12.7	45.9 ± 12.7	50.4 ± 12.1	0.01
Men, %	66	62	75	0.04
Follow-up, y	10.2 ± 2.0	10.1 ± 2.1	10.7 ± 1.5	0.01
Blood pressure, mm Hg				
Systolic	152 ± 21	150 ± 19	157 ± 24	0.01
Diastolic	95 ± 11	94 ± 10	98 ± 12	0.01
Duration of hypertension, y	8.3 ± 9.3	8.5 ± 9.2	8.1 ± 9.0	> 0.2
White, %	92	95	87	0.13
Creatinine level, μmol/L (mg/dL)	115 ± 18 (1.3 ± 0.2)	115 ± 18 (1.3 ± 0.2)	124 ± 18 (1.4 ± 0.2)	> 0.2
Cholesterol level, mmol/L (mg/dL)	6.5 ± 1.4 (251 ± 56)	6.5 ± 1.5 (250 ± 58)	6.5 ± 1.4 (253 ± 53)	> 0.2
Smokers, %	17	17	16	> 0.2
Medical treatment, %	79	78	83	> 0.2
Height, cm	172 ± 11	172 ± 11	172 ± 10	> 0.2
Weight, kg	77 ± 16	77 ± 15	79 ± 17	> 0.2

* Data are expressed as mean ± SD.

cardiography as part of research studies at the New York Hospital-Cornell Medical Center between 1976 and 1981. The 376 patients considered for analysis gave a complete history and had a physical examination and an evaluation for secondary hypertension before echocardiography was done. The evaluation for secondary hypertension included, but was not limited to, plasma renin measurements and 24-hour urine collections to measure sodium and aldosterone excretion. M-mode echocardiograms of excellent or good quality were obtained for 309 patients (82%). Mean systolic and diastolic blood pressures were calculated from clinical measurements obtained within 30 days of echocardiography.

Patients with secondary hypertension (7), pre-existing cardiac disease (15), or pre-existing medical illnesses that affect longevity, such as diabetes (7), were excluded from the analysis. After exclusions were made, 280 patients from the original group, 76 of whom were among the group of patients reported in our previous shorter-term study (18), were included in the analysis. Electrocardiograms obtained at the time of the initial evaluation, available for review for 91% of patients, were examined for evidence of left ventricular hypertrophy using Sokolow-Lyon (21), Cornell (22), and Romhilt-Estes (23) (≥ 4 points) criteria.

Clinical Follow-up

Telephone interviews were conducted with patients or their immediate family members to determine the incidence of complications of hypertension. Complications included death (15), stroke (11), myocardial infarction (20), new-onset angina (22), congestive heart failure (3), coronary revascularization by surgery (11) or angioplasty (6), and carotid endarterectomy (1). Reports of complications were corroborated by patients' physicians, hospital records, and death certificates whenever possible.

Myocardial infarction was diagnosed only when at least two of the three standard criteria were met (typical symptoms, electrocardiographic changes, and transient elevation of myocardial enzymes). Stroke was diagnosed on the basis of objective persistent neurologic deficits, as documented by a physician. Angina was diagnosed when a chest pain syndrome led to ischemic cardiac events (12), coronary revascularization (6), or an evaluation confirming the clinical diagnosis of angina (3). Investigators were blinded to the results of echocardiography during interviews with patients and when classifying possible morbid events.

Echocardiograms

M-mode echocardiograms were obtained with commercially available echocardiographs using 13-mm 2.25-MHz transducers

and following standard procedures for the visualization of the left ventricle (24). Echocardiographic tracings were coded and interpreted blindly by two investigators who had no knowledge of the identity or clinical characteristics of patients. The inter-ventricular septum, left ventricular internal dimension, and posterior wall thickness were measured at end-diastole according to the recommendations of the American Society of Echocardiography and the Penn convention. Measurements made according to the Penn convention recommendations were used to calculate left ventricular mass by an anatomically validated formula (25, 26). Measurements made according to the recommendations of the American Society of Echocardiography were used to calculate end-diastolic relative wall thickness as the ratio of posterior wall thickness to one-half left ventricular internal dimension (27).

The left ventricular mass index was calculated for each patient by dividing left ventricular mass by body surface area. This index was used to adjust for variations in cardiac size that are attributable to differences in body size (17, 28). Because this method of indexation might lead to under-recognition of obesity-related hypertrophy (29), we did alternative analyses using left ventricular mass-to-height ratios.

We prospectively chose 125 g/m² as a cutoff point to detect left ventricular hypertrophy. This value, which identified hypertensive men at high cardiovascular risk in a previous study (18), corresponds to approximately the 95th percentile of left ventricular mass in two normal samples studied in our laboratory (28, 30). The same partition value was applied to women on the basis of evidence from the Framingham study that high-risk status was identified in women and men by similar levels of indexed left ventricular mass (19, 20). Patients were further categorized on the basis of whether their relative wall thickness ratio fell within normal limits (< 0.45) (31). Patients with increased ventricular mass were considered to have concentric left ventricular hypertrophy if their relative wall thickness ratio was elevated (≥ 0.45) or eccentric hypertrophy if their relative wall thickness ratio was normal. Those with normal ventricular mass were considered to have concentric remodeling if their relative wall thickness ratio was elevated; they were considered to have normal left ventricular geometry if their relative wall thickness ratio was normal (32).

Statistics

Computer analyses were done using the BMDP biomedical statistical software (BMDP Statistical Software, Berkeley, California) (33). T-tests for continuous variables and the chi-square test for dichotomous variables (for example, race, sex) were used for univariate comparisons between groups. A stepwise logistic regression analysis was done to estimate the in-

dependent risk for cardiovascular complications associated with age, sex, blood pressure (systolic and diastolic), serum cholesterol level, and left ventricular mass. Variables were retained in logistic equations only if the *P* value for removal was less than 0.05 and their coefficient to standard error (SE) ratio was 2 or more. Life table and Cox proportional hazard analyses were used to generate curves of actuarial and projected survival among groups of patients; these curves were compared using Breslow and Mantel test statistics. Confidence intervals (CIs) of 95% were used where appropriate.

Results

Detailed follow-up data were obtained for 253 (90%) of the patients who met entry criteria. The demographic characteristics of these patients are listed in Table 1. Left ventricular mass index was at least 125 g/m² in 31% of the men and 20% of the women. Patients with left ventricular hypertrophy were, on average, older and had higher blood pressure than did those with normal left ventricular mass, but the groups did not differ in serum cholesterol level or cigarette smoking. Approximately four fifths of both groups received antihypertensive medication during much or all of the time since baseline echocardiography was done. Beta blockers were used in 56% of patients; diuretics, in 51%; angiotensin-converting enzyme inhibitors, in 14%; calcium-channel blockers, in 10%; and other classes of agents, in 10%. Some overlap between agents resulted from multidrug therapy or serial monotherapy. There was no important difference in the type of drug used between patients with and patients without hypertrophy at baseline or between patients with and patients without morbid events during follow-up.

The 27 patients who were lost to follow-up differed from the patients with longitudinal follow-up: They were disproportionately black (26% compared with 8%; *P* < 0.005) and tended to be younger (43 compared with 47 years of age). The patients who were excluded because of technically suboptimal echocardiograms were

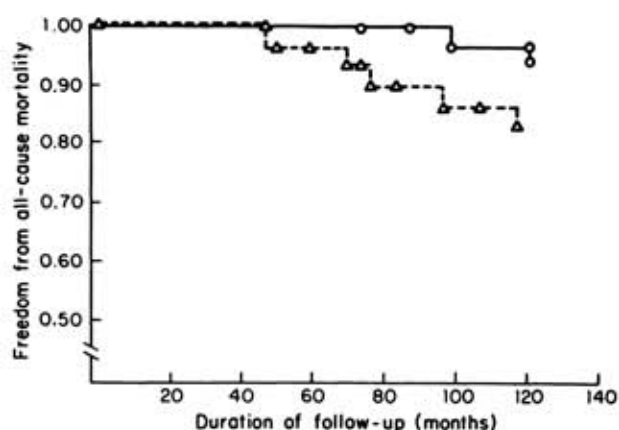


Figure 1. Survival in 280 patients with essential hypertension, including 77 patients with left ventricular hypertrophy (Δ) and 203 patients without hypertrophy ($\circ$) (*P* < 0.001). Ninety-four percent of patients were alive and were observed for at least 84 months; 60% were observed for 120 months or longer.

older than the study sample (53 compared with 47 years of age; *P* < 0.05).

We documented one or more cardiovascular events in 40 patients (Table 2). There were 15 deaths (6%) in the contacted group; 11 deaths were from cardiovascular causes. Seven patients who died had nonfatal complications before their terminal event occurred. Four additional deaths among the 27 patients lost to follow-up were ascertained by National Death Index data.

Cardiac mortality was strongly concentrated in both men (6 of 7 deaths) and women (4 of 4 deaths) with increased left ventricular mass index. All cardiovascular events were more common in both men (13 of 52 or 25% compared with 15 of 114 or 13%; *P* = 0.06) and women (5 of 17 or 29% compared with 7 of 70 or 10%; *P* = 0.04) with increased ventricular mass. Nonfatal

Table 2. Fatal and Total Events during Follow-up

Event	Left Ventricular Mass Index		<i>P</i> Value*
	< 125 g/m ²	≥ 125 g/m ²	
	<i>n</i> (%) [95% CI]		
All deaths			
By study data (<i>n</i> = 253)	4 (2) [0-6]	11 (16) [7-25]	0.001
By study data and the National Death Index data (<i>n</i> = 280)	8 (4) [1-7]	11 (14) [7-22]	0.002
Cardiovascular deaths	1 (1) [0-4]	10 (14) [6-23]	< 0.001
Sudden death	0	2	
Cerebrovascular accident	0	1	
Myocardial infarction	1	5	
Congestive heart failure	0	2	
At least one cardiovascular event	22 (12) [7-17]	18 (26) [16-36]	0.006
Total events			
New angina	15	7	
Myocardial infarction	9	11	
Coronary bypass	5	6	
Angioplasty	2	4	
Congestive heart failure	1	2	
Stroke	7	4	
Carotid endarterectomy	1	0	

* According to chi-square analysis.

cardiovascular events occurred in over twice the proportion of patients with left ventricular hypertrophy compared with those with normal mass, predominately because of a higher risk for myocardial infarction and for surgical or nonsurgical coronary revascularization (1.6 compared with 0.5 events per 100 patient-years [$P = 0.01$] and 1.5 compared with 0.4 events per 100 patient years [$P = 0.01$], respectively). The association between increased ventricular mass and cardiovascular death is stronger (Table 2) than that between increased ventricular mass and nonfatal cardiovascular events.

Electrocardiographic hypertrophy patterns were detected in only 9 of 38 (24%) patients with events using all criteria and in fewer patients using single criteria (Sokolow-Lyon [3 patients], Cornell [4 patients], Romhilt-Estes [6 patients]). Of 192 patients without events, 34 (18%) had electrocardiographic left ventricular hypertrophy according to one or more criteria (Sokolow-Lyon [27 patients], Cornell [4 patients], Romhilt-Estes [11 patients]).

Life-table analyses showed highly significant differences in event-free survival ($P = 0.01$), cardiovascular death ($P < 0.001$), and total mortality ($P < 0.001$) between patients with and patients without left ventricular hypertrophy (Figure 1). These differences persisted after adjustment for age using the Cox analysis. Figure 2 shows projected, age-adjusted, event-free survival for our patients with and our patients without left ventricular hypertrophy.

Table 3 compares morbid events among subjects divided according to demographic and biochemical measures, showing that older patients and those with higher blood pressure and serum cholesterol values were more likely to have adverse outcomes. However, in stepwise logistic regression analyses, only age and left ventricular mass emerged as independent predictors of cardiovascular death, cardiovascular events, or all-cause mortality (Table 4). Significant univariate relations with

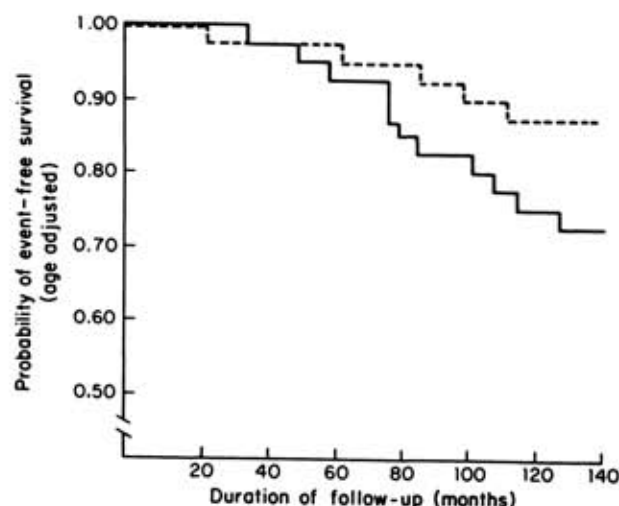


Figure 2. Age-adjusted, cardiovascular event-free survival in 253 patients with essential hypertension, including 69 patients with left ventricular hypertrophy (—) and 184 patients without hypertrophy (---) ($P = 0.01$). Data are adjusted for age using a Cox analysis. Eighty-five percent of the patients were event-free and were followed for at least 84 months; 51% were event-free and were followed for at least 120 months.

Table 3. Cardiovascular Events in Relation to Baseline Variables

Variables	Patients with Events % (95% CI)	P Value*
Age, y		
< 50	7 (3-11)	
≥ 50	26 (18-34)	< 0.001
Sex		
Men	17 (10-24)	
Women	14 (7-21)	> 0.2
Systolic blood pressure, mm Hg		
< 150	10 (5-15)	
≥ 150	24 (16-32)	0.03
Diastolic blood pressure, mm Hg		
< 100	13 (8-18)	
≥ 100	25 (14-36)	0.02
Race		
White	17 (12-23)	
Black	7 (1-36)	> 0.2
Cholesterol level, mmol/L (mg/dL)		
< 6.2 (240)	11 (5-16)	
≥ 6.2 (240)	20 (14-27)	0.04
Smoking status		
Nonsmokers	17 (11-22)	
Smokers	12 (4-27)	> 0.2
Left ventricular mass index, g/m ²		
< 125	12 (7-17)	
≥ 125	26 (16-36)	0.006

* According to chi-square analysis.

blood pressure levels and cholesterol concentration were not noted after age and left ventricular mass were entered in logistic equations. Cigarette smoking was not a significant predictor of prognosis in either univariate or multivariate analyses. Indexing of left ventricular mass for height did not alter the results of univariate or multivariate analyses.

Relative wall thickness ratios also provided useful prognostic information (Table 5). Patients with normal left ventricular architecture had the best prognosis (the incidence of cardiovascular events among these patients was 11%; there were no cardiac deaths), and those with concentric left ventricular hypertrophy had the worst prognosis (the incidence of cardiovascular events among these patients was 31%; the rate of cardiovascular death was 20%). Figure 3 graphically depicts the proportions of patients who had cardiovascular events and of those who died in each of the four groups. Similarly, all-cause mortality, calculated for the total series of 280 patients using National Death Index data, was lowest in patients with normal ventricular geometry (4 of 166 patients or 2%), intermediate in those with concentric remodeling (4 of 37 patients or 11%) or eccentric hypertrophy (4 of 43 patients or 9%), and highest in those with concentric hypertrophy (7 of 34 patients or 21%) ($P = 0.008$ by analysis of variance). Table 5 also shows events per 100 patient-years for each group, taking into account multiple events in individual patients. "Hard" endpoints (excluding angina) were nearly fivefold more frequent in patients with hypertrophy than in patients with normal cardiac geometry.

Discussion

Recently reported studies have shown that increased left ventricular mass detected by echocardiography predicts increased cardiovascular morbidity and mortality during relatively short-term follow-up (≤ 4.5 years) of men with essential hypertension (18), patients with chronic renal failure (34) or coronary artery disease (35), and middle-aged and elderly members of the general population (19, 20). Our study's results extend these observations by documenting that, in well-characterized patients with essential hypertension, left ventricular mass is a strong predictor of prognosis in women as well as men; an increased risk for adverse outcomes persists over the long term, with no attenuation over 10 years despite conventional hypertensive treatment of most patients; left ventricular mass is a stronger risk factor than blood pressure, cigarette smoking, or total cholesterol level; left ventricular hypertrophy is a highly sensitive predictor of cardiovascular death; and risk can be better stratified by considering left ventricular geometric pattern in addition to considering muscle mass.

Hypertension, a strong risk factor for cardiovascular morbidity, is the most common antecedent of left ventricular hypertrophy in the general population and the most common cardiovascular condition necessitating medical management. The 253 patients whom we followed for 10 years had a moderate prevalence of increased ventricular mass at baseline (27%); a high incidence of cardiovascular death, myocardial infarction, angina, stroke, or congestive heart failure (2.6 events per 100 patient-years); and the expected positive relation between systolic arterial pressure and morbid events. However, the association with each of the three measurements of outcome in the study (cardiovascular death, all-cause mortality, and total cardiovascular events) was consistently weaker for either systolic or diastolic blood pressure than for left ventricular mass. Further, the inclusion of ventricular mass in multivari-

ate equations eliminated the prognostic importance that we found in univariate analyses for systolic blood pressure and serum cholesterol level (Table 4). Cardiovascular risk was similar among men and women when the same level of indexed left ventricular mass was used to define hypertrophy in both genders. In fact, only left ventricular mass and age were independent predictors of each outcome measurement; this finding is consistent with the conclusion of the Framingham investigators (presented without supporting analyses) that "age was the only variable other than left ventricular mass that showed consistent and strong relations to the incidence of all three outcome events in both sexes" (20).

Why left ventricular hypertrophy predisposes patients to morbid events is incompletely understood, but may be related to its role as a variable that both integrates various adverse effects on the heart and sensitizes the heart to morbid events. Left ventricular hypertrophy reflects pressor responses to normal activity (36) and physical exercise (37) as well as effects of nonpressure stimuli to cardiac growth, such as obesity (38, 39), high salt intake (39, 40), and elevated blood viscosity (41). All of these factors are known or suspected to be stimuli to coronary and extracardiac atherosclerosis. Further, in dogs, repeated episodes of transient myocardial ischemia may induce hypertrophy (42), and standardized coronary artery ligation caused myocardial infarction more consistently, resulted in larger infarcts, and led to a higher incidence of sudden death in animals with concentric left ventricular hypertrophy (43, 44). These data suggest that hypertensive patients with left ventricular hypertrophy are particularly likely to have coronary and extracoronary arterial disease and are at a disadvantage when coronary artery occlusion occurs. Our finding that hypertensive patients with increased left ventricular mass were more likely to experience cardiac death, myocardial infarction, or coronary syndromes necessitating coronary revascularization, but

Table 4. Prediction of Outcome Using Logistic Multivariate Analysis*

Variables	Univariate F Statistic (P Value)	Regression Coefficient (P Value)
Cardiovascular death (11 of 253 patients)		
Age	19.9 (< 0.001)	- 0.22 (< 0.001)
Cholesterol level	1.3 (> 0.2)	NS (> 0.2)
Systolic blood pressure	9.9 (0.002)	NS (> 0.2)
Diastolic blood pressure	0.1 (> 0.2)	NS (> 0.2)
Sex	0.3 (> 0.2)	NS (0.13)
Left ventricular mass index	37.1 (< 0.001)	- 0.034 (< 0.001)
All-cause mortality (19 of 280 patients)		
Age	20.0 (< 0.001)	- 0.10 (< 0.001)
Cholesterol level	1.3 (> 0.2)	NS (> 0.2)
Systolic blood pressure	6.7 (0.007)	NS (> 0.2)
Diastolic blood pressure	0.2 (> 0.2)	NS (> 0.2)
Sex	0.1 (> 0.2)	NS (> 0.2)
Left ventricular mass index	20.4 (< 0.001)	- 0.019 (0.002)
Nonfatal plus fatal cardiovascular events (40 of 253 patients)		
Age	22.4 (< 0.001)	- 0.074 (< 0.001)
Cholesterol level	5.1 (0.026)	NS (> 0.2)
Systolic blood pressure	11.3 (< 0.001)	NS (> 0.2)
Diastolic blood pressure	3.6 (0.058)	NS (0.18)
Sex	0.4 (> 0.2)	NS (> 0.2)
Left ventricular mass index	14.0 (< 0.001)	- 0.013 (0.01)

* NS = not significant.

Table 5. *The Relation between Morbid Events and the Pattern of Ventricular Geometry*

Morbid Event	Patient Group				P Value*
	Normal Geometry (n = 150)	Concentric Remodeling (n = 34)	Eccentric Hypertrophy (n = 40)	Concentric Hypertrophy (n = 29)	
Cardiovascular deaths, %	0	3	10	21	< 0.001
Cardiovascular events, %	11	15	23	31	0.03
All deaths, %	1	6	10	24	< 0.001
Events per 100 patient-years, n					
All cardiovascular events	1.8	4.2	7.1	5.2	
Stroke	0.4	0.3	0.7	1.0	
New angina	0.6	1.2	1.2	0.7	
All events except for angina and stroke	0.6	2.7	5.2	3.4	

* By analysis of variance.

that they were no more likely than those without hypertrophy to have the milder clinical presentation of new onset angina is consistent with this hypothesis.

Although the prognostic value of left ventricular mass for morbid events was striking, it could be improved by more detailed consideration of cardiac geometry (Table 5 and Figure 3). Patients with concentric hypertrophy (increased relative wall thickness and mass) had the highest likelihood of dying or having a cardiovascular event. Among patients with eccentric hypertrophy (normal relative wall thickness despite increased mass), a smaller percentage of patients had several, frequently nonfatal, morbid events.

This result is new, but not altogether surprising. Previous studies conducted in hypertensive patients have shown associations between concentric left ventricular hypertrophy and increased peripheral resistance and noncoronary vascular disease (45), decreased coronary vasodilator reserve (46), and impaired coronary autoregulation during lowering of blood pressure (47), all of which suggest an enhanced susceptibility to vascular events. In contrast, eccentric ventricular hypertrophy has been associated most strongly with ventricular arrhythmias (48) and depressed left ventricular functional response to stress (49), which might predispose patients to sudden death (50) and congestive heart failure—endpoints that were uncommon in our study. The increased risk in patients with concentric ventricular remodeling (a high relative wall thickness ratio without increased mass) suggests that this patient group may share pathophysiologic abnormalities with the concentric hypertrophy group.

One notable result of our study was that the excess risk associated with increased left ventricular mass at baseline persisted for more than 10 years (Figures 1 and 2), despite the use of conventional antihypertensive treatment in most patients. This outcome, although disappointing, is consistent with the modest (at best) cardiac benefit that was achieved in large treatment trials (2-6). Our patients were treated with various agents, most commonly beta-blockers and diuretics. No important relation between the type or number of agents used and the presence of either ventricular hypertrophy or morbid events was noted ($P > 0.1$). Whether the adverse prognosis associated with ventricular hypertrophy would have been improved by the consistent use of

antihypertensive drugs that are thought to benefit the heart more (51) is at present unknown.

The results of our study have striking implications for risk stratification in hypertensive patients. Cardiac events occurred at an extremely high rate (5.4 per 100 patient-years) in the 69 (27%) of our patients who had increased ventricular mass and at a very low rate (0.6 per 100 patient-years) over 10 years among the 65 (26%) of our patients who had normal ventricular geometry,

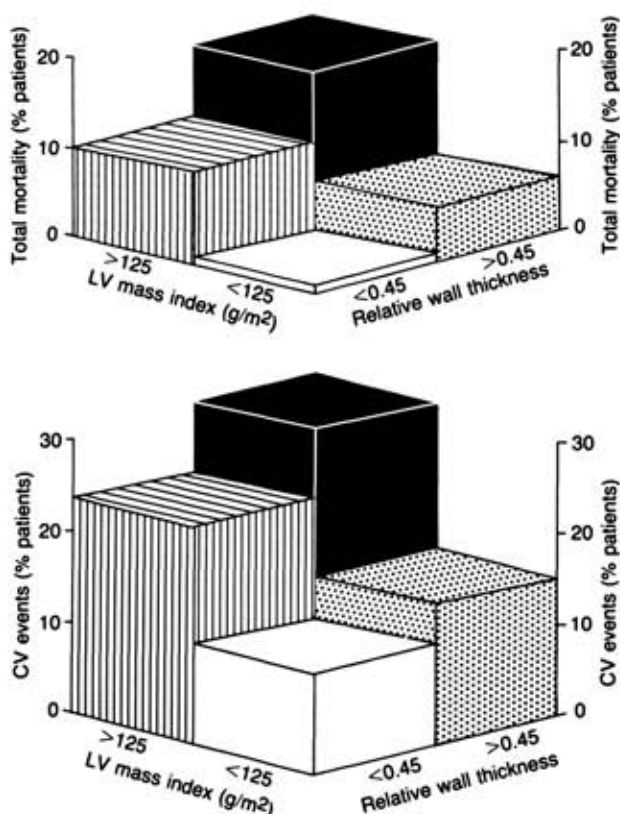


Figure 3. The relation of total mortality (*top*) and cardiovascular (CV) events (*bottom*) to patterns of left ventricular (LV) geometry in 253 patients with essential hypertension. Mortality and event rates are highest in patients with concentric hypertrophy (■), lowest in patients with normal ventricular geometry (□), and intermediate in patients with eccentric hypertrophy (▨) and concentric remodeling (▤) ($P < 0.001$ for total mortality and $P = 0.03$ for CV events by analysis of variance).

did not smoke, and had cholesterol and diastolic blood pressure levels of less than 6.2 mmol/L (240 mg/dL) and 105 mm Hg, respectively. If standard antihypertensive therapy had only a modest effect on outcome in our patients, as is suggested by the results of large trials, treating the former group intensively and deferring treatment or using nonpharmacologic modalities in the latter group would be appropriate. Further research is needed to determine whether reversal of left ventricular hypertrophy with the use of antihypertensive agents reduces high risk and whether the low-risk group of mildly hypertensive patients with normal ventricular geometry and no other cardiovascular risk factors can be safely assigned to receive nonpharmacologic therapy.

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